General Services Administration
Public Buildings Service

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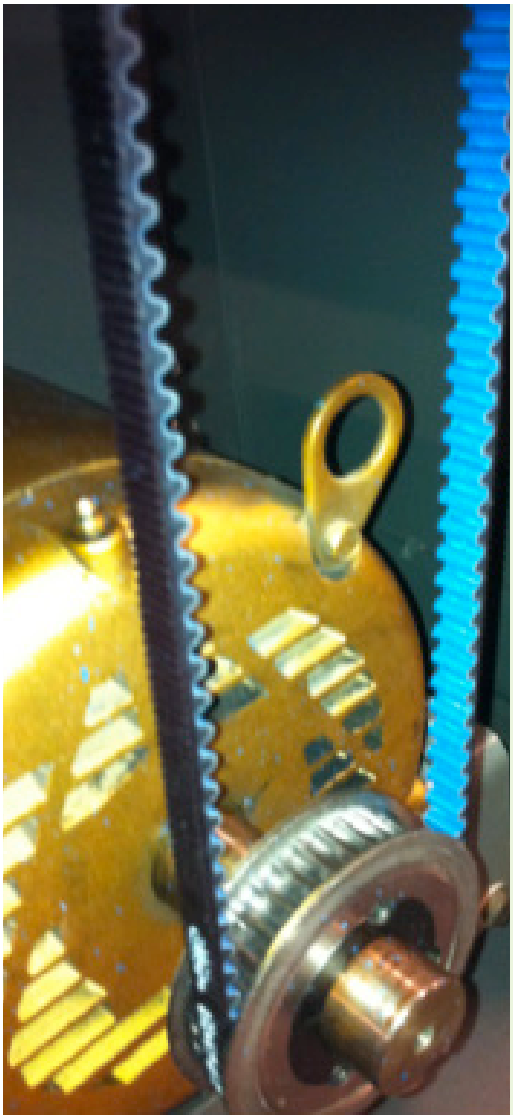
SYNCHRONOUS AND COGGED FAN BELTS



Synchronous and Cogged Fan Belts Improve Efficiency, Save Energy

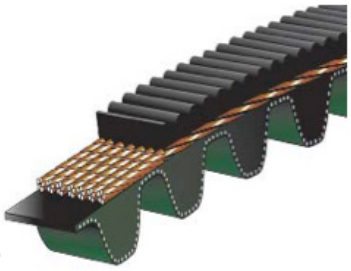
Ventilation fans consume a significant portion of the electricity used in U.S. commercial buildings. In fact, ventilation accounts for approximately 12% of total commercial-building electricity use.[1] Total fan energy use is higher still, due to the presence of belt-driven fans in cooling towers and other non-ventilation applications. Inefficiencies account for some of this electricity use, specifically losses that occur during the transfer of energy between motor shafts and fans. Two innovative fan belt technologies that replace the standard V-belt address this issue. Cogged V-belts reduce the amount of material on the inner surface of the belt, and are designed to reduce the bending resistance as the belt travels around the sheave. Synchronous drive belts have teeth that integrate with slots in the sheave (much like a bicycle or motorcycle drive) and are designed to reduce both belt slippage and frictional losses. Belt manufacturers claim energy savings of up to 5% for synchronous drive belts[2] and 2% for cogged V-belts.[3] While this is a small portion of overall building electricity use (between 0.3% and 0.5%), this technology offers a simple and inexpensive way of reducing ventilation energy use. Recently, GSA's GPG program Rocky Mountain Region, put synchronous drive belts and cogged V-belts to the test on two different fans in the Byron G. Rogers Federal Building and U.S. Courthouse in Denver, Colorado. Findings included energy savings up to 20% and simple payback for synchronous drive belts of less than four years.

The GPG program enables GSA to make sound investment decisions in next generation building technologies based on their real world performance.

INTRODUCTION

A.

B.



C.

A. Standard V-Belt

B. Cogged V-Belt
Reduces bending resistance and friction.

C. Synchronous Drive Belt
Reduces belt slippage and friction.

" Converting from standard V-belts to synchronous and cogged fan belts saved energy, and the new belts require less maintenance. Overall, this project was a great success."

—Joe Baker
Downtown Denver Project Manager and Equipment Management Specialist
GSA

PERFORMANCE SPECIFICATIONS
Energy Efficiency

INCUMBENT	
V-Belts	**95%**
NEW FAN BELTS	
Cogged V-Belts	**97%**
Synchronous Drive Belts	**99%**

What We Did

RESEARCHERS COMPARED BOTH BELTS TO INCUMBENT TECHNOLOGY

The Rocky Mountain Region GPG team commissioned the National Renewable Energy Laboratory (NREL) to perform measurement and verification of cogged V-belts and synchronous drive belts on both a constant volume (CV) and a variable air volume (VAV) fan at the Byron G. Rogers Federal Building and U.S. Courthouse. These motor/fan combinations were tested with their original, standard V-belts to obtain a baseline for standard operation. The standard V-belts were then replaced with cogged V-belts, and finally with synchronous drive belts. The power consumption by the motor was normalized for both fan speed and air density changes. Energy savings and operation and maintenance (O&M) savings were compiled into an economic life-cycle cost analysis of the different belt options.

What We Measured

MONITORING ENCOMPASSED SEVERAL CRITICAL VARIABLES

Monitoring consisted of measuring real and apparent electricity consumption, fan speed, motor speed, and sound level of the two fans with their original V-belts, then repeating the measurements for the cogged V-belts and the synchronous drive belts. Electrical performance was monitored for each belt placed on the CV fan for a period of between 3 and 5 minutes, with data recorded at one-second intervals. Monitoring captured both the start-up and the steady-state operation of the CV fan. The variable frequency drive (VFD) on the VAV fan was placed into "hand mode" and the frequency was set manually in increments of 5 hertz (Hz), from 15 to 60 Hz (the maximum), to capture the performance at different fan speeds. Approximately 2 to 3 minutes of metered data were recorded at each frequency, along with fan speed, motor shaft speed, and ambient noise.

FINDINGS

CONSISTENT ENERGY SAVINGS FOR BOTH COGGED AND SYNCHRONOUS BELTS On the VAV fan, the synchronous drive belts demonstrated energy savings that ranged from 2.3% (at 60Hz) to 20.1% (at 15 Hz). Savings for the cogged V-belts ranged from 1.2% (at 60Hz) to 9.3% (at 15 Hz). On the CV fan, cogged V-belts demonstrated savings over standard V-belts, particularly with small-diameter motor or fan sheaves and in instances where the installed V-belt was oversized for the sheave diameter.

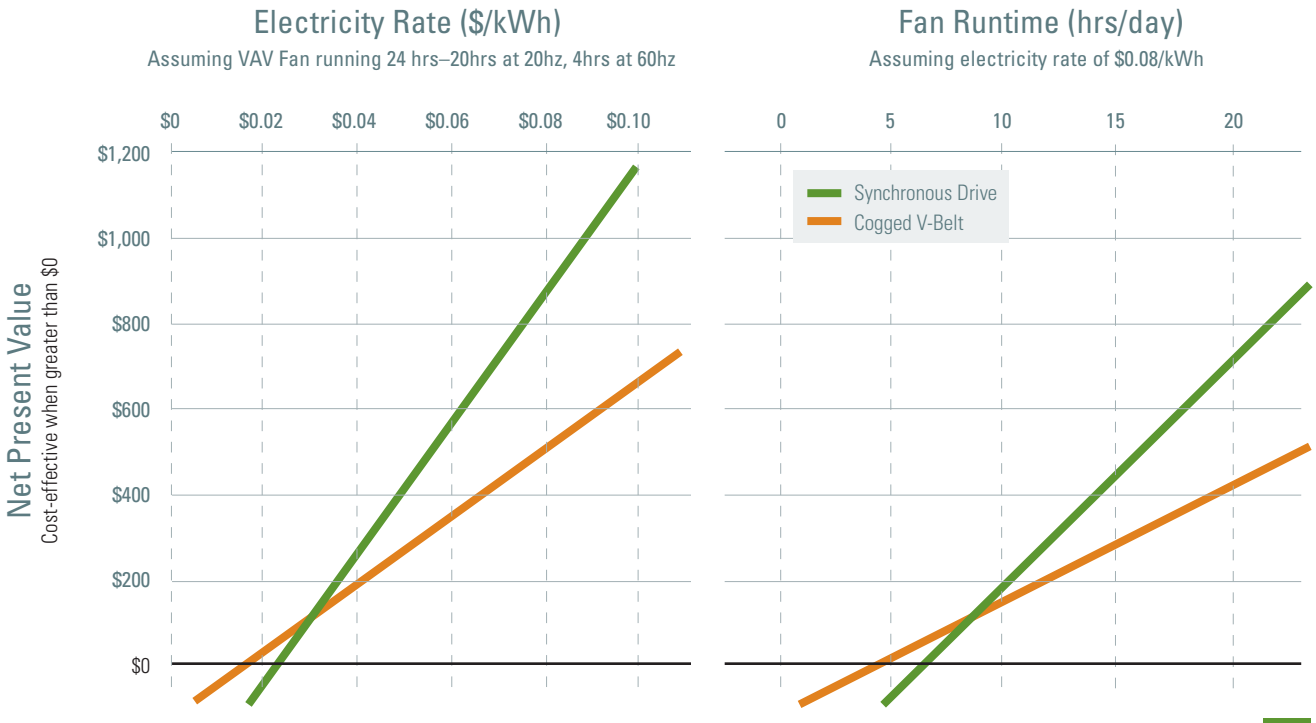
SYNCHRONOUS BELTS DEMONSTRATE LOWEST LIFE-CYCLE COSTS AND SIMPLE PAYBACK OF LESS THAN 4 YEARS Despite significantly higher initial costs, synchronous drive belts demonstrated lower life-cycle costs than cogged and standard V-belts. This was due to a combination of reduced energy consumption and O&M costs, as well as a reduction in the number of belts required: one synchronous drive belt replaced four V-belts. For this analysis, the belts were all assumed to have equivalent lifespans. The synchronous drive belt's manufacturer claims a longer lifespan. If this is true, it would only improve that belt's economics.

PROPER INSTALLATION IS CRITICAL While cogged V-belts do not require any additional installation costs over standard V-belts, synchronous drive belts require sheave replacement. Also, to maintain optimal fan speeds, it is critical that belts are properly sized. This is less of an issue with VAV fans, which will readjust the frequency of the drive to deliver the required flow. In the case of CV fans, any increase in fan speed due to belt sizing will likely outweigh the savings from the synchronous drive belts. This barrier to adoption recommends against the use of synchronous drive belts for CV fans.

VAV FANS WITH HIGH OPERATING HOURS ARE BEST CANDIDATES FOR REPLACEMENT Energy savings and payback argue for deployment of synchronous drive belts on all VAV systems; belts on fans with high operating hours should be replaced first. Cogged V-belts should be installed on all CV fans when the incumbent V-belts are replaced through the standard O&M program.

Net Present Value Increases as Electricity Costs & Runtime Increase

Synchronous cost-effective at $0.024 kWh, 6.8 hrs/day; Cogged cost-effective at $0.015 kWh, 4.3 hrs/day



CONCLUSIONS

These Findings are based on the report, "Synchronous and Cogged Fan Belt Performance Assessment," which is available from the GPG program website, www.gsa.gov/gpg

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What We Concluded

SYNCHRONOUS DRIVE BELTS AND COGGED V-BELTS BOTH REDUCE ENERGY CONSUMPTION

Both synchronous drive belts and cogged V-belts reduced energy consumption when compared with the incumbent V-belt technology. Savings were greater on the VAV fan and were highest at lower fan speeds. Both types of belt demonstrated a lower life-cycle cost than the standard V-belt. For cogged V-belts, this was due solely to reduced energy usage; O&M costs stayed the same and the cost of the belts themselves was only slightly higher. For synchronous drive belts, lower life-cycle costs were a result of greater energy savings, a 75% reduction in O&M costs, and competitive belt replacement costs: one synchronous drive belt can perform the task of multiple V-belts.

Lessons Learned

CORRECT FAN CHOICE AND EXPERT INSTALLATION ARE KEY

Synchronous drive belts and cogged V-belts provide a relatively simple, low-cost way of achieving energy savings, but they must be installed correctly and applied in appropriate situations.

- For VAV fans, the synchronous drive belts performed well and showed savings at all ranges of fan operation.
- For CV fans, cogged V-belts are the best solution. Synchronous drive belts pose risks when combined with the CV fan's high-torque starts and increased operational speed.
- With both types of belt, higher operating hours and higher electricity costs will result in shorter payback periods.
- No significant change was noted in the sound levels generated by different belt operation.

Reference above to any specific commercial product, process or service does not constitute or imply its endorsement, recommendation or favoring by the United States Government or any agency thereof.

Footnotes

[1]Buildings Energy Data Book. http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=3.1.4 Accessed 7/20/12.

[2]Energy Savings from Synchronous drive belts. The Gates Corporation. http://www.gates.com/ptPartners/file_display_common.cfm?thispath=Gates%2Fdocuments_module&file=Energy%20Savings%20from%20Synchronous%20Belt%20Drives.pdf&location_id=3427. Accessed 26 June 2012.

[3]Energy Tip Sheet #5. Motor Systems. Industrial Technologies Program. Office of Energy Efficiency and Renewable Energy. Department of Energy. September 2005. http://www1.eere.energy.gov/manufacturing/tech_deployment/pdfs/replace_vbelts_motor_systemts5.pdf. Accessed 26 June 2012.

Technology for test-bed measurement and verification provided by Gates Corporation.